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(71) Applicant

Toshiba Kikai Kabushiki Kaisha

(Incorporated in Japan)

2-11 Ginza 4-chome, Chuo-ku, Tokyo 104, Japan

(72) Inventors

Susumu Harada
Hideo Tanaka

(74) Agent and/or Address for Service

Mewburn Ellis & Co,
2/3 Cursitor Street, London EC4A 1BQ

(51) INT CL⁴

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B5A

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B29F

(54) A method of controlling mold clamping and compression in an injection molding machine

(57) The movable and fixed mold halves (17, 18) are positioned with a spacing (δ) and molten resin is injected into the mold cavity (22) via an injection cylinder (19), the mold half (17) then being moved to close the mould halves together to compress the resin.

To achieve good molding reproducibility, the velocity or velocity slope of the movement of the moving die plate (12), is controlled to a required program as the mold half (17) moves in the gap (δ). This control may be on the basis of successive positions of the moving die plate (12) either as detected by detector (23), which then is used with the program of a setting unit (27) to produce a velocity error signal in a comparator (26), to control the hydraulic source (29) which powers the piston (15) controlling the moving die plate, or the velocity control may be on the basis of successive time intervals, or of the velocity at successive positions, or time intervals for part of the movement and pressure for the remainder of the movement.

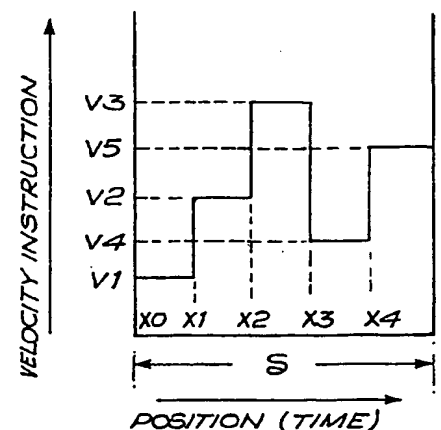
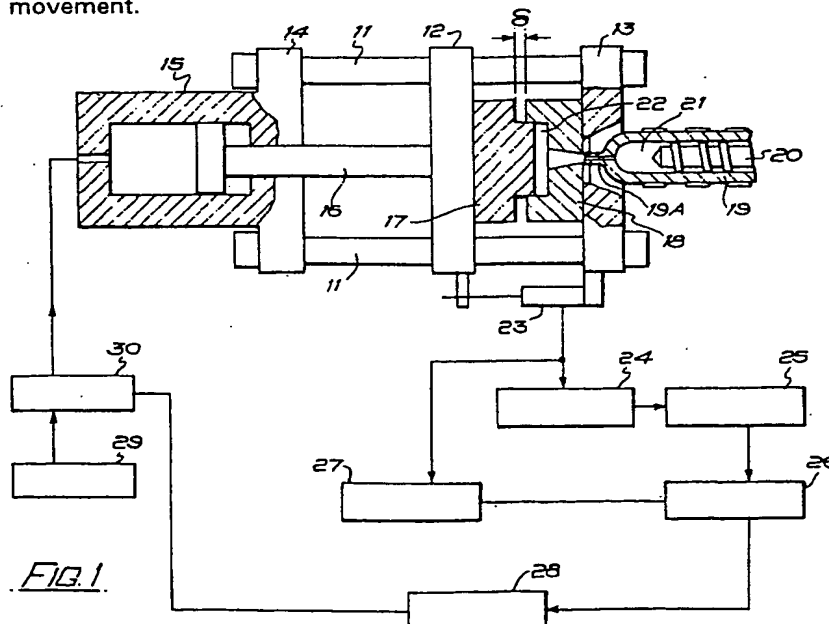


FIG. 4

1-4

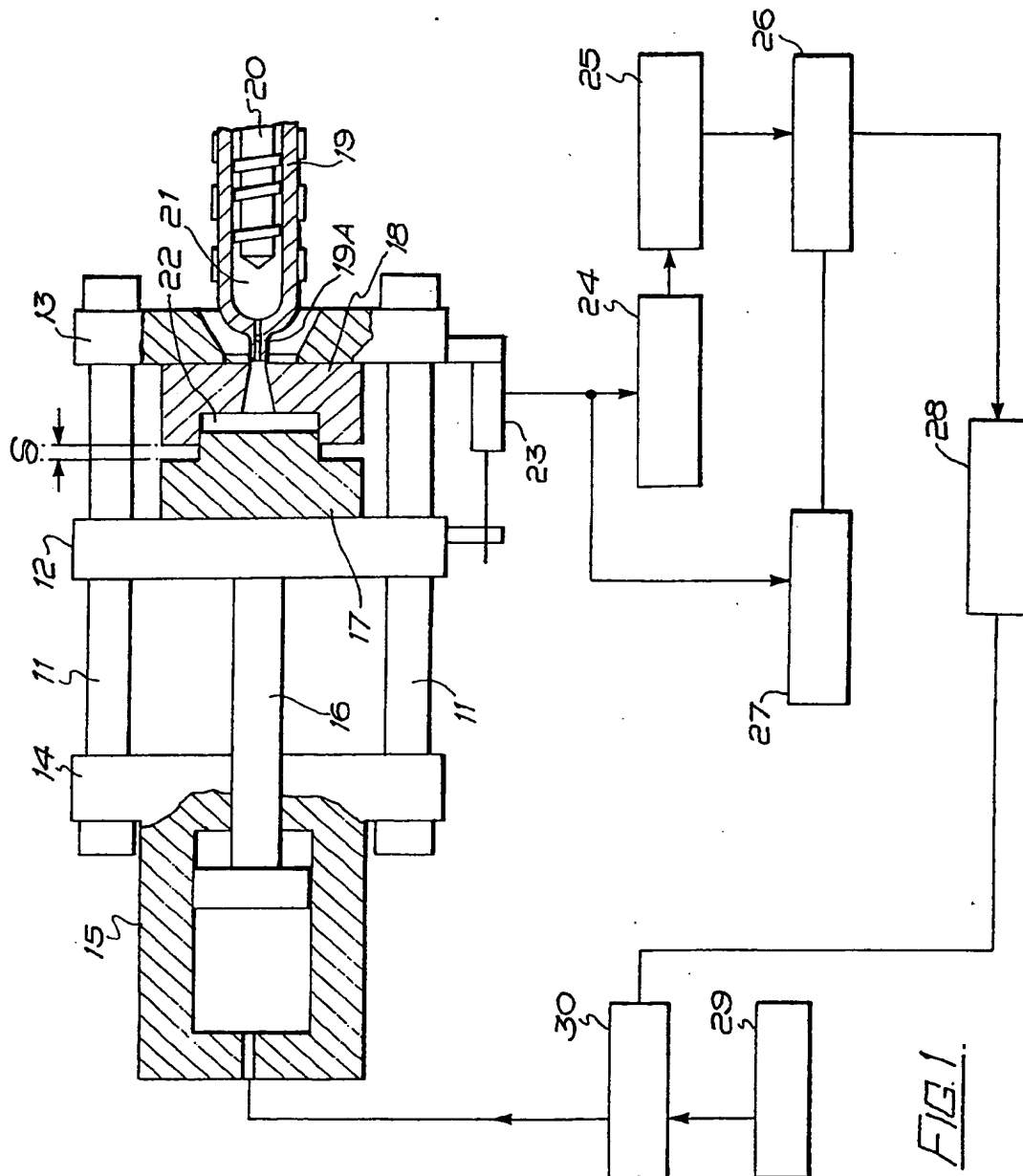


FIG. 1

2.4

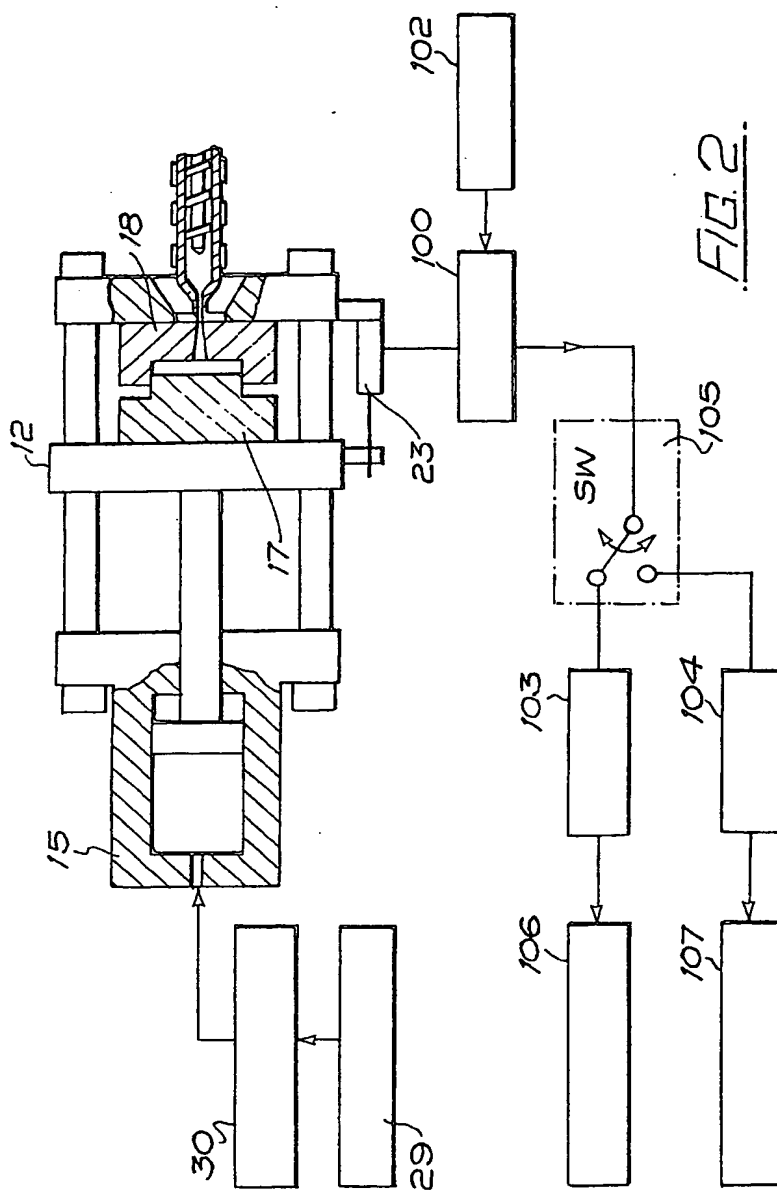


FIG. 2

3.4

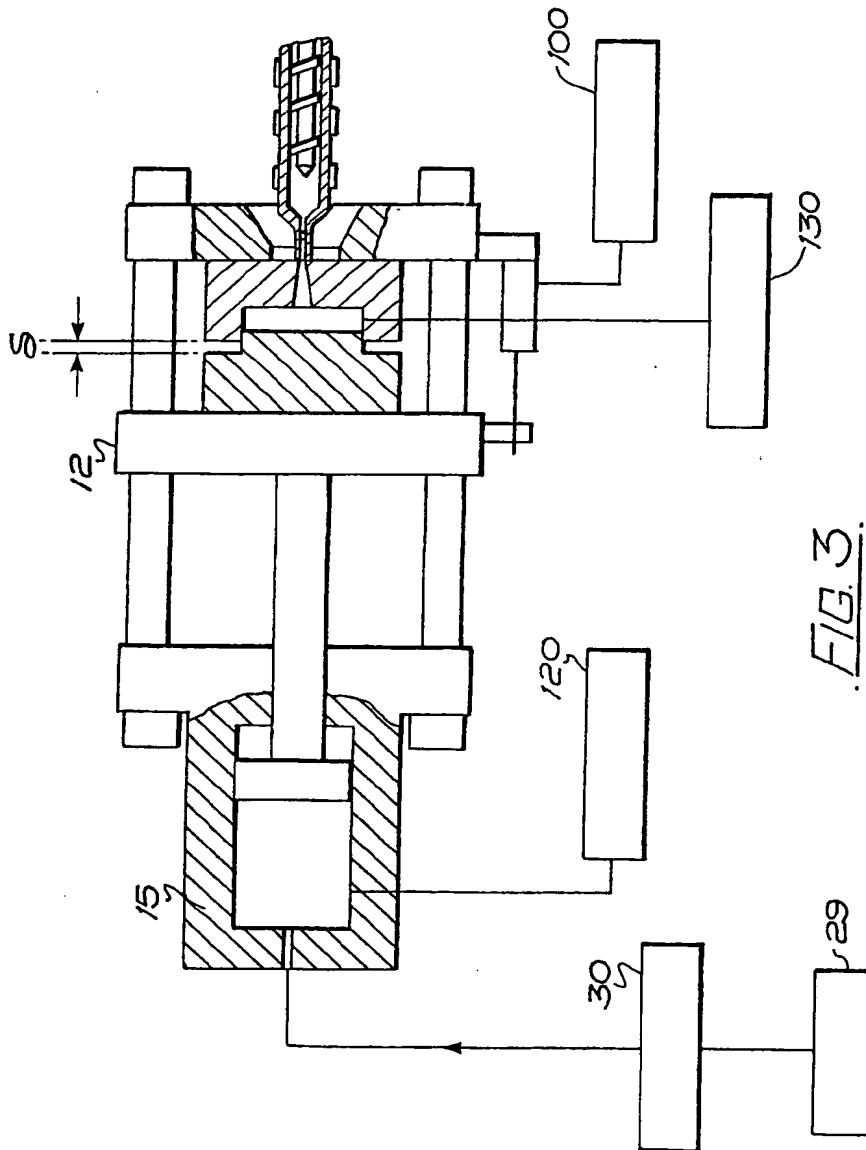
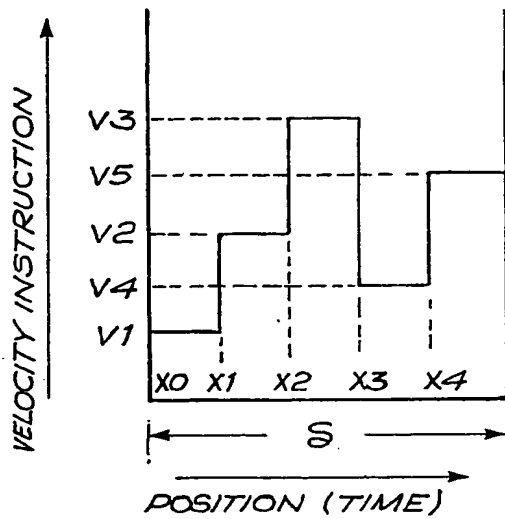
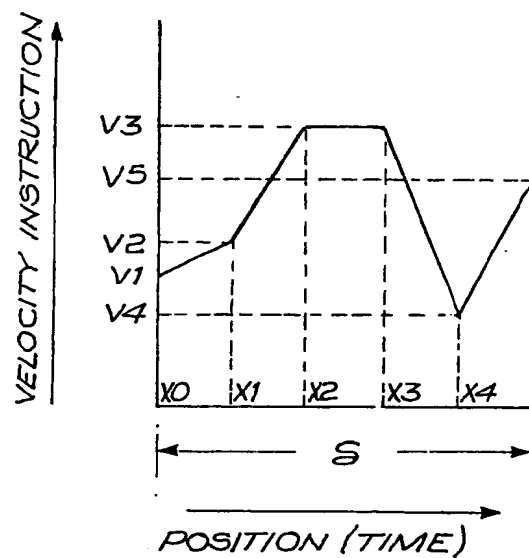
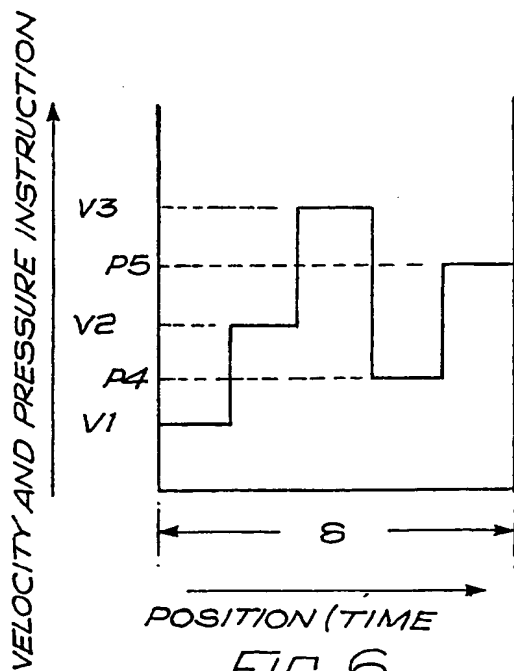


FIG. 3

4.4

FIG. 4FIG. 5FIG. 6

SPECIFICATION

A method of controlling mold clamping and compression in an injection molding machine

This invention relates to a method and apparatus for controlling the mold clamping and compression in an injection molding machine.

In particular it controls the gap between a pair of mold dies in a mold clamping and compression process wherein a gap is formed for compressing resin injected into a mold cavity prior to the compression.

In a conventional type of injection molding machine, the mold clamping and compression for compressing resin molded in a cavity is controlled by a programmed control method wherein the values of pressure to be compressed are programmed in accordance with positions of the injection plunger or screw mounted on the machine, or in accordance with a plurality of time intervals in pressure holding operation of injection control process.

Accordingly, it is impossible accurately to mold such articles with sufficient reproducibility when molding with thin plates or resin with high viscosity by applying a programmed control method of mold clamping and compression (hereinafter called compression process) in which only the molding pressure is controlled.

Furthermore, even though the preset molding pressure is accurately controlled in each molding operation, the velocity of the moving die during the compression in the compression process is not kept constant and becomes unstable because of changes in the temperatures of the mold dies and pressurised oil needed for operation, and results in problems to mold articles with good reproducibility.

Therefore, the present invention seeks to provide a method for controlling an injection molding machine wherein velocity control is applied to the mold clamping control process in order to mold articles with high reproducibility.

The present invention has been devised by noticing the fact that the drawbacks of the prior art is attributed on the basis of the fundamentals in which the mold clamping control process is controlled by controlling only the clamping pressure.

The present invention provides a method wherein velocity control is applied to the mold clamping control process, thereby eliminating or reducing the drawbacks of the prior art methods.

To achieve such velocity control it is possible for the control to be on the basis of successive positions of the moving die half, or on the basis of successive time intervals in that movement. It is also possible for the velocity control to be applied only over a limited part of the compression, in order to im-

prove reproducibility, and subsequently at any set time after injection of resin, the velocity control mode is switched to a pressure control mode, e.g. using single or multi-step programmed clamping pressure control.

The velocity control may be achieved using a closed loop multi-step programmed velocity control mode or a closed loop multi-step programmed velocity slope control mode.

According to the present invention, it becomes possible to mold articles with high reproducibility and high density.

Embodiments of an injection molding machine of the present invention will now be described in detail, by way of example, with reference to the accompanying drawings; in which:

Fig. 1 illustrates diagrammatically a first embodiment of the present invention in which velocity control is applied during compression in a mold clamping control process;

Fig. 2 illustrates diagrammatically a second embodiment of the present invention on which both velocity control and compression pressure control is applied during compression in a mold clamping control process;

Fig. 3 illustrates diagrammatically various detectors used for the position detector in Fig. 2;

Fig. 4 is a graph illustrating velocity instructions corresponding to positions within a compression gap δ in a closed loop multi-step programmed velocity control mode;

Fig. 5 is a graph illustrating velocity instructions corresponding to positions within a compression gap δ in a closed loop multi-step programmed velocity slope control mode; and

Fig. 6 is a graph illustrating velocity and pressure instructions corresponding to positions within a compression gap δ in a closed loop multi-step programmed velocity control and clamping pressure control.

Embodiment 1

In Fig. 1, there is shown an embodiment of the present invention in which a flange of a clamping cylinder 16 has the left-most ends of tie bars 11 fixedly mounted thereon. The right-most ends of tie bars 11 are fixed on a fixed die plate 13.

A moving die plate 12 is slidably mounted on the tie bars 11, and a mold half 17 is mounted on the moving die plate 12. Another mold die half 18 is mounted on fixed die plate 13.

A piston rod 16 of a cylinder 15 is fixedly connected to the moving die plate 12.

Molten resin 21 in an injection cylinder 19 is injected into a cavity 22 through a channel 19A by means of a screw 20 during an injection molding control process.

Before molten resin 21 is injected into the cavity 22, the moving die plate 12, carrying the mold die half 17, is moved to a position corresponding to a selected compression gap

δ , at which the mold die half 17 is displaced from the other mold die half 18 by the gap (δ).

A position detector 23 is mounted on the fixed die plate 13, which continuously detects the positions of moving die plate 12, and hence the mold die half 17.

A sampling unit 24 electrically processes the detected position value and used to calculate the velocity at each position.

A setting unit 27 stores a multi-step program or a slope program for controlling the velocity of the moving die plate 12 in the compression gap δ . These programs stored in the setting unit 27 are started by a signal supplied from a position detector 23. The setting unit 27 produces a velocity instruction signal corresponding to each position of the die plate 12 within the compression gap δ .

A velocity detector 25 produces a signal representing the actual velocity of moving die plate 12.

A comparator 26 produces a velocity error signal corresponding to the difference between the signal from the velocity detector 25 and that from the setting unit 27.

A servo amplifier 28 amplifies the signal from the comparator 26 so as to operate an electro-magnetic servo valve to which hydraulic pressure oil from a hydraulic source 29 is supplied.

As shown in Fig. 1, prior to injection for filling cavity 22 with molten resin 21, the mold die half 17 mounted on the moving die 12 is held at a position corresponding to the compression gap δ , then the cavity 22 is filled with molten resin 21 by an injection operation.

Immediately after cavity 22 is filled, a mold clamping control process, that is, a compression process for further compressing the molten resin in the cavity 22 is executed until the spacing between the mold halves becomes zero.

The graph in Fig. 4 shows the velocity instructions V1, V2, V3, V4, V5 from the setting unit 27 corresponding to positions X0, X1, X2, X3 and X4 during the compression process. The graph in Fig. 5 shows velocity slope instructions between V1, V2, V3, V4, V5 from the setting unit 27 corresponding to positions X0, X1, X2, X3, X4 and X5 during the compression process.

According to the present invention, the velocity of compression in the injection molding machine is stabilised at least in the early stages of compression, and errors in the clamping velocity, derived from the temperature drift of the metal dies or of hydraulic oil, are reduced, so that a stabilised injection molding process can be accomplished repeatedly.

Embodiment 2

65. The second embodiment differs from the

first embodiment with respect to the compression process.

The second embodiment is described using the simple case of detecting the position of the moving die plate as described in the first embodiment.

In Fig. 2, the position of moving die plate 12 corresponding to a selected compression gap is set in a gap position setting unit 22 and a clamping velocity control program and clamping pressure control program are set in setting units 103 and 104 respectively.

In early stages of the clamping process, the position of selectable switch 105 is selected so that it is connected to a clamping velocity control unit 106, and as hydraulic source 29 is operated, the mold die 17 reaches a position corresponding to a compression gap δ .

After the mold die 17 reaches the position corresponding to the compression gap δ , the flow of hydraulic oil to the clamping cylinder 15 is controlled by an electro-magnetic servo valve 30 and the moving die plate 12 is controlled and moves with a single or multi-step programmed velocity control, determined by setting unit 103, as shown in Fig. 6. (Velocities, V1, V2 and V3 at each position X0, X1 and X2.)

When the moving die plate 12 reaches the predetermined position set by setting unit 102, the selectable switch 105 is changed to connect to the setting unit 104 by a signal from a position detector 100 in order to switch to clamping pressure control, and the mold clamping process is controlled with single or multi-step programmed pressure control in accordance with a program set in setting unit 104, as shown in Fig. 6. (Pressures P1, P2 at positions X3, X4.)

In Fig. 2, the timing of the switching of the selectable switch 105 from connection to setting unit 103 to connection to setting unit 104 is defined by the signal from position detector 100.

Fig. 3 illustrates a detector 130 to detect resin pressure in the cavity or a clamping pressure detector 120, which may be used instead of, or working in co-operation with, the position detector 100.

In Fig. 1, the setting unit 27 produces signals corresponding to a plurality of instruction velocities in accordance with position signals from the position detector 23. However, this may be modified to form another setting unit different from the setting unit 27 shown in Fig. 2. This other setting unit may be formed so as to produce signals corresponding to a plurality of instruction velocities in accordance with a plurality of time intervals during which the moving die plate stays at each region within the compression gap δ . In such a case, the other setting unit is provided with a timer counter. In Fig. 4, Fig. 5 and Fig. 6, a time control may be substituted for position control, as shown in parentheses. Similar modifi-

cation may be applied to both setting units 103 and 104.

As described above, the present invention may permit several programmed conditions to be set for various kinds of resin or for various types of mold dies. Furthermore, excellent molded articles with high reproducibility can be made by applying velocity control to the mold clamping control, particularly during the early stages of the compression process, and articles with high density can be made stably by applying pressure control in later stages of the compression process.

CLAIMS

1. A method of controlling the mold clamping and compression of molten resin injected into a cavity in an injection molding machine, which machine has a moving die plate carrying a first mold die half and a fixed die plate carrying a second mold die half; the method comprising:
moving the moving die plate to a predetermined position to define a compression gap between the die halves, prior to injection of the molten resin;
injecting the molten resin into the cavity; and
moving the moving die plate towards the fixed die plate to compress the molten resin; wherein the velocities of movement of the moving die plate are controlled in dependence on the movement of the first mold die half in the compression gap.

2. A method according to claim 1, wherein the velocities of movement of the moving die plate are controlled with respect to successive positions of the first mold die half.

3. A method according to claim 1, wherein the velocities of movement of the moving die plate are controlled in dependence on successive time intervals of the movement of the first mold die half.

4. A method according to claim 1, wherein the velocities of movement of the moving die plate are controlled in dependence on successive positions of the first mold die half in a first part of the compression gap, and the velocities of movement of the moving die plate are controlled in dependence on predetermined pressures which change with respect to successive positions of the first mold die half in a second part of the compression gap.

5. A method according to any one of the preceding claims, wherein the velocities of movement include a velocity slope defined between two positions in the compression gap.

6. A method of controlling the mold clamping and compression of molten resin injected into a cavity in an injection molding machine, substantially as any one herein described with reference to and as illustrated in the accompanying drawings.

7. An apparatus for controlling the mold clamping compression of molten resin injected

into a cavity in an injection molding machine having a moving die plate carrying a first mold die half and a fixed die plate carrying a second mold die half, which apparatus comprises:

70 means for driving the moving die plate;
means for detecting the position of the moving die plate and producing a signal representing the actual velocity of the moving die plate;

75 a velocity instruction means generating a signal representing a selected velocity of the moving die plate during the compression;
a comparison means for producing an error signal from a comparison of the signal representing the selected velocity and the signal representing the actual velocity; and
80 a drive control means responsive to the error signal for producing a drive signal to drive means.

85 8. An apparatus for controlling the mold clamping and compression of molten resin injected into a cavity in an injection molding machine having a moving die plate carrying a first mold die half and a fixed die plate carrying a second mold half, which apparatus comprises:

means for driving the moving die plate;
means for detecting the position of the moving die plate during the compression and producing a signal representing the actual position of the moving die plate, and producing a change-over signal when the moving die plate reaches a predetermined position set by a position setter;

100 a mold clamping velocity instruction means for generating a signal representing a selected velocity of the moving die plate during the compression;

a mold clamping velocity control means responsive to the signal representing the selected velocity for applying a drive signal to the drive means;

105 a mold clamping pressure instruction means for instructing a pressure in the cavity during the compression;

110 a mold clamping pressure control means responsive to the instructed mold clamping pressure for applying a drive signal to the drive means; and

115 a switch means responsive to the change-over signal for changing over from the mold clamping velocity instruction means to the mold clamping pressure instruction means.

9. An apparatus for controlling the mold clamping and compression of molten resin injected into a cavity in a molding machine substantially as herein described with reference to and as illustrated in Fig. 1 or Fig. 2 or Fig. 3 of the accompanying drawings.

125

CLAIMS

Amendments to the claims have been filed, and have the following effect

130 Claims 7 and 8 above have been deleted or

textually amended.

New or textually amended claims have been filed as follows:

7. An injection molding system comprising
- 5 an injection molding machine having a moving die plate carrying a first mold die half and a fixed die plate carrying a second mold die half defining an injection cavity therebetween, and an apparatus for controlling the mold clamping
- 10 compression of molten resin injected into the cavity, which apparatus comprises:
- means for driving the moving die plate;
- means for detecting the position of the moving die plate and producing a signal representing the actual velocity of the moving die
- 15 plate;
- a velocity instruction means generating a signal representing a selected velocity of the moving die plate during the compression;
- 20 a comparison means for producing an error signal from a comparison of the signal representing the selected velocity and the signal representing the actual velocity; and
- a drive control means responsive to the error signal for producing a drive signal to drive means,
- 25
8. An injection molding system comprising an injection molding machine having a moving die plate carrying a first mold die half and a
- 30 fixed die plate carrying a second mold half defining an injection cavity therebetween, and an apparatus for controlling the mold clamping and compression of molten resin injected into the cavity, which apparatus comprises:
- 35 means for driving the moving die plate;
- means for detecting the position of the moving die plate during the compression and producing a signal representing the actual position of the moving die plate, and producing
- 40 a change-over signal when the moving die plate reaches a predetermined position set by a position setter;
- a mold clamping velocity instruction means for generating a signal representing a selected
- 45 velocity of the moving die plate during the compression;
- a mold clamping velocity control means responsive to the signal representing the selected velocity for applying a drive signal to
- 50 the drive means;
- a mold clamping pressure instruction means for instructing a pressure in the cavity during the compression;
- a mold clamping pressure control means responsive to the instructed mold clamping
- 55 pressure for applying a drive signal to the drive means; and
- a switch means responsive to the change-over signal for changing over from the mold
- 60 clamping velocity instruction means to the mold clamping pressure instruction means.